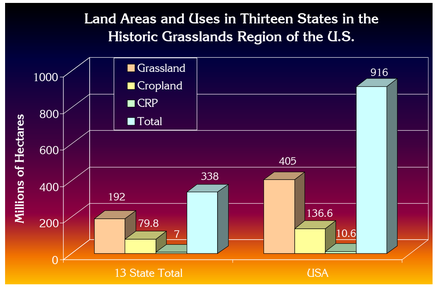
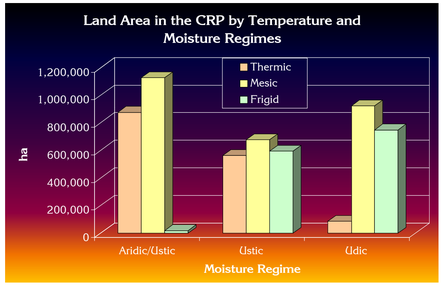
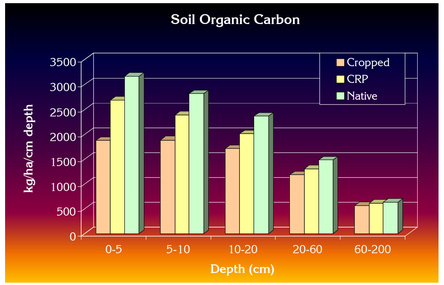
Carbon Storage in Historic Grassland Soils of the USA Under Native, CRP, and Cropland Conditions

S.E. Samson-Liebig*, R.F. Follett, E.G. Pruessner, and J.M. Kimble
USDA-ARS and USDA-NRCS







INTRODUCTION

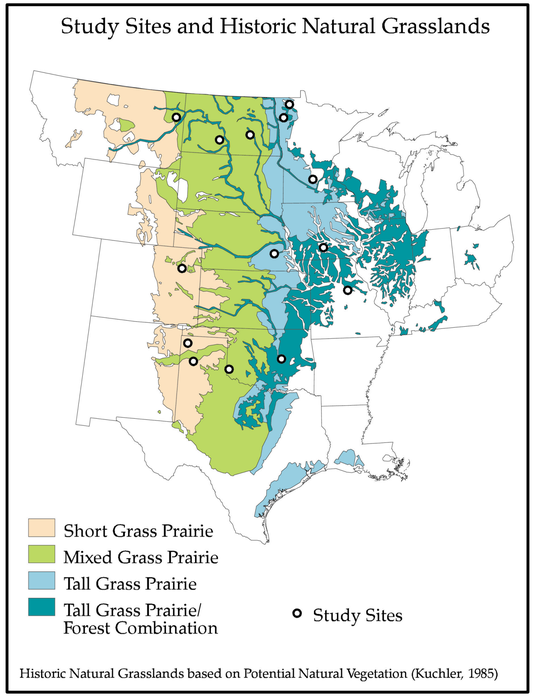
Since 1994, scientists from the Agricultural Research Service and the Natural Resources Conservation Service have been collaborating to investigate the soil organic carbon (SOC) storage within soils in the Historical Grasslands area of the USA found in native, the Conservation Reserve Program (CRP), and cropland conditions. This project included sites in nine states within the thirteen-state coverage of the Historic Grassland region. Information and data are needed to answer questions about the effect of CRP and its impact on SOC storage in the soil profile, as well as on soil quality. The primary users of this information to date have been policy makers in Washington, DC, carbon modelers, and other interested scientists studying soil carbon dynamics.

This paper will illustrate the effects of temperature gradients coupled with land use (CRP) on SOC within the native grassland area. From this study, we will be able to evaluate long-term losses and gains of SOC in the soil profile and to examine the potential for using the CRP to sequester SOC in soils.

Across the thirteen-state region, 21 percent of the total U.S. land area is within the Historical Grasslands region. This includes the states of Alaska and Hawaii. The area represented in this study is 66 percent (7 million ha) of the total 10.6 million ha of land currently enrolled in the CRP through Sign-Up 19 (excluding Sign-Up 18). Our research focused on the effect of the CRP and soil carbon dynamics in the CRP within a matrix of nine temperature by moisture regimes in this region. Total land area encompassed in the nine temperature by moisture regimes is 5.62 million ha or 53 percent of the total 10.6 million ha of land currently enrolled in the CRP.

METHODS

Typical sites representing major land uses were selected in eastern Colorado, eastern Nebraska, central Iowa, eastern Montana, northwestern Texas, central Missouri, central and northwestern Minnesota, western and central Oklahoma, and western and central North Dakota. At each site, native, CRP, and cropland conditions were located in the same map unit and geomorphic setting. The average enrollment time for CRP across all sites was 7.9 years. Soil samples were collected from soil pits dug to two meters. Each site was described and other field measurements were taken such as Ksat and infiltration. Soil organic carbon was determined by dry combustion.



Historic Natural Grasslands based on Potential Natural Vegetation (Kuchler, 1985)

USDA NRCS
Natural Resources Conservation Service

SOIL SURVEY 1899 1999 CENTENNIAL

RESULTS and DISCUSSION

Temperature

Temperature regime consistently affected the amount of SOC in CRP at $P > 0.05$ for the 0-5 cm, 0-10 cm, 0-20 cm, and 0-200 cm depths and at $P > 0.10$ for the 0-60 cm and 0-100 cm depths. The total stock of SOC was the lowest in the thermic temperature regime and highest in the mesic and frigid regimes. These data show large SOC stocks with depth in grassland soils. Soil organic carbon stocks in land enrolled in CRP in the study area averaged 105 MT C ha^{-1}. Estimated total SOC stocks to 2 m depth under the 7 million ha CRP within this region is about 0.74 Pg, which is about half of the total emissions of CO_2 in the U.S.

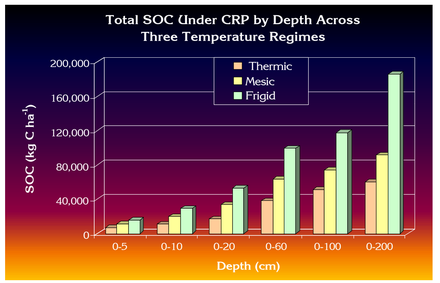
SOC Sequestration

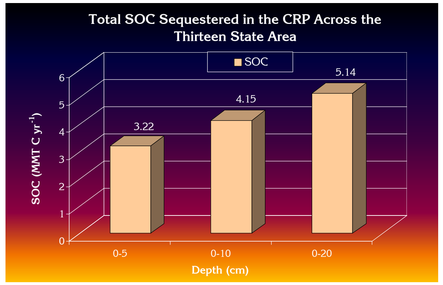
Regional average-annual SOC sequestration rates in the CRP within the study area was derived by the difference in the amount of SOC measured in soils in CRP minus that measured for soils in cropped sites, then multiplied by the corresponding land area in the CRP for each depth increment. Thus, the rates determined within the 5.6 million ha area of the study region are 567, 738, and 914 kg SOC ha^{-1} yr^{-1} for the 0-5, 0-10, and 0-20 cm depths, respectively. These rates are similar to other studies that are based upon actual physical measurements.

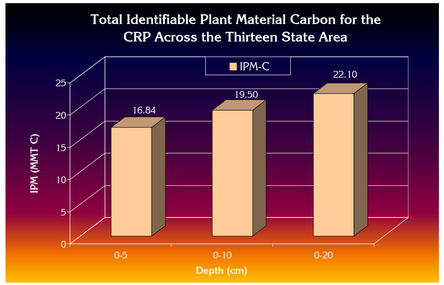
Results indicate that leaving soils in CRP or grassland in these areas will sequester significant amounts of soil carbon. Furthermore, if a sequestration rate in the top 20 cm of soil is 900 kg SOC ha^{-1} yr^{-1}, then 9.5 MMTC would be sequestered annually in all land that is currently enrolled in the CRP, thus offsetting about 20 percent of agriculture's CO_2 emissions.

Identifiable Plant Material (IPM) Carbon

Regional average amounts of IPM-C were calculated similar to that of SOC. Average amount of IPM-C in CRP was about 2990, 3470, and 3930 kg C ha^{-1} more than in the cropped sites at 0-5, 0-10, and 0-20 cm depths, respectively.







SUMMARY

- The soils in the Historic Grasslands of the U.S. contain over 100,000 kg SOC/ha to a depth of 2 meters or a total of 192,000 MMTC with about 40,000 MMTC being in the top 10 cm.
- Carbon sequestration resulting from the CRP in the thirteen-state Historical Grasslands in this study is about 5.1 MMTC yr^{-1} in the top 20 cm and about 3.2 MMTC yr^{-1} in the surface 5 cm. Because of its near surface location, this sequestered carbon is highly vulnerable to loss by land management practices that expose it to soil erosion and other possible loss mechanisms.
- In 0-5 cm, 0-10 cm, and 0-20 cm depth, 567, 738, and 914 kg SOC ha^{-1} yr^{-1}, respectively, was sequestered in CRP based upon the difference in the amount of SOC for CRP minus that measured for soil in cropland.
- Soils in the frigid/udic regimes had the highest potential for C sequestration.
- The soils in the Historic Grasslands region of the U.S. provide a huge reservoir to store carbon. These soils, under the current CRP enrollment, could offset about 20 percent of all U.S. agricultural emissions.